Supplemental Materials for: Conditioning-Free Mg Electrolyte by Minor Addition of $Mg(HMDS)_2$

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Table S1: Water content of various solutions measured by Karl Fischer Titration.

solution	THF	MACC	MACC + 2 mM $Mg(HMDS)_2$
water content (ppm)	22	71	46

Increased water content in MACC is attributed to water present in the salts. In MACC + 2 mM $Mg(HMDS)_2$, although more salt is added to the solution, water content decreases, confirming the water-scavenging effect of $Mg(HMDS)_2$.

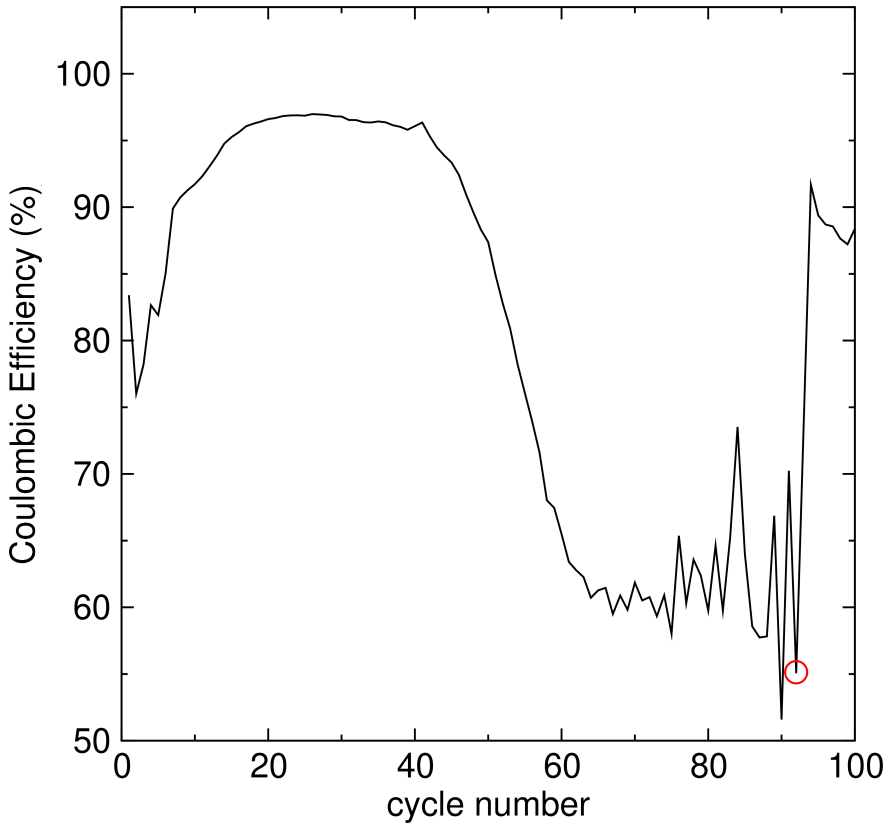

Figure S1: Typical Coulombic efficiency profile of MACC + 10 mM $Mg(HMDS)_2$. CE decreases due to the formation of a black film. The black film is easily removed from the Pt wire by simple agitation. The electrolyte reaches >90% CE upon when the black film is removed from the electrolyte (red circle).

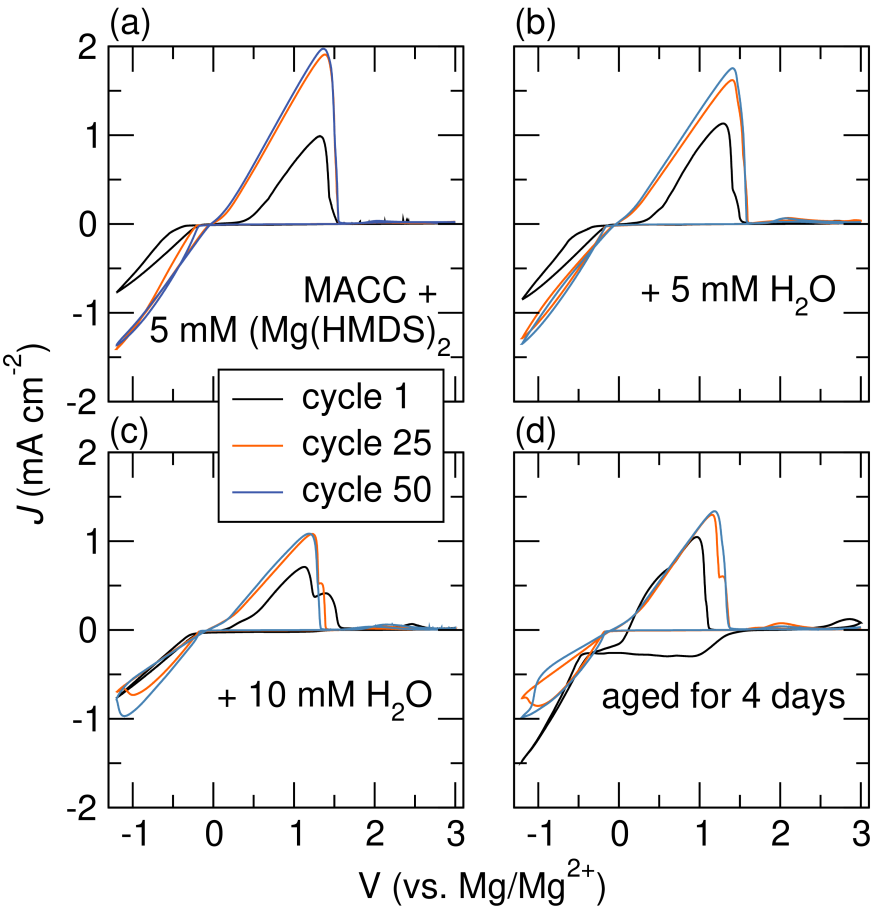

Figure S2: Cyclic voltammograms of cycles 1, 25, and 50 of (a) MACC + 5 mM $Mg(HMDS)_2$, (b) MACC + 5 mM $Mg(HMDS)_2$ + 5 mM and (c) 10 mM H_2O, and (d) MACC + 5 mM $Mg(HMDS)_2$ aged for 4 days. MACC + 5 mM $Mg(HMDS)_2$ with and without H_2O exhibit similar electrochemical behavior, including Mg deposition/stripping and no cathodic current in the fourth quadrant from cycle 1. MACC + 5 mM $Mg(HMDS)_2$ + 5 mM H_2O exhibits >99% Coulombic efficiency at cycle 50 while MACC + 5 mM $Mg(HMDS)_2$ + 10 mM H_2O exhibits 84% at cycle 50, likely due to the high concentration of H_2O in the solution. The electrolyte does not exhibit cathodic current in the fourth quadrant with 10 mM of H_2O addition. In comparison, MACC + 5 mM $Mg(HMDS)_2$ aged for 4 days exhibits cathodic current in the fourth quadrant, the region attributed to Al deposition, in cycle 1. The cathodic current in aged MACC + 5 mM $Mg(HMDS)_2$ that disappears in subsequent cycles may be due to the depletion of free Cl^- during aging.